91602
new 82-10

COMPLIMENTARY COPY
Please Credit Ontario Hydro Research if
Reproduced in Whole or in Part

ontario hydro
research division

To Mr. M. L. Eisner
Materials Safety Officer
Divisional Services Department

HUMAN FACTORS ASSESSMENT OF TASKS ASSOCIATED WITH 20-TON HYDRAULIC LOAD FRAME FOR IN SITU SOIL TESTING

S.C. McCann

A Human Factors assessment of the 20 Ton Hydraulic Load Frame was performed to assess the physical demands associated with it. Watback, a 2 dimensional static strength program was used to calculate the compressive loads on the L4-L5 disc of the spine. Video analysis was performed to identify aspects of the Load Frames design that could be improved to reduce the amount of lifting and the need for awkward postures.

1.0 INTRODUCTION

A human factors assessment was done for tasks associated with the 20-ton hydraulic load frame for in situ soil testing at Cranberry Junction on June 12, 1991. The goal of the assessment was to determine if any of the lifts that are made while using the rig pose a significant risk of musculoskeletal injury to the operators. The assessment included videotaping as well as taking still pictures for use with Watback, a 2-dimensional static strength program that calculates the moments around each joint and the compression at the L4-L5 disc of the spine. Four lifts were analyzed using WATBACK. The 4 different lifts that were analyzed included the lift of the 5 foot auger from the platform (Figure 1), lift of 5 foot auger from the ground (Figure 2), lifting the 5 foot Aw rod with one hand (Figure 3), and lifting a 10 foot Aw rod with one hand. The videotape analysis was performed to determine other tasks associated with the technician's job that may pose a risk of injury as well as to evaluate the design of the rig from an ergonomic standpoint.

job	file	date	report no.
40-508-002	843.	September 9, 1991	91-208-K

2.0 WATBACK ANALYSIS

Watback was developed at the University of Waterloo. It was designed to calculate the load placed on joints and the lower back while lifting. The calculated loads are compared to an existing database so that it can be determined if a lift is acceptable or excessive. The Watback output that is of most concern in this case is the calculation of the compressive load at L4-L5 of the lower spine. The National Institute for Occupational Health and Safety (NIOSH) has done research into the effects of compression at the L4-L5 level of the spine. From this research they have derived two limits for compression at L4-L5. The first limit is called the Action Limit and is equal to 3433 N. If the calculated compression on the spine is below the AL during a lift there is nominal risk to most workers. In fact, over 75% of females and 99% of males can lift loads described by the AL. If the compression exceeds AL, there is an increased risk of injury unless personnel are carefully selected and trained for the lifting task. The second limit NIOSH sets is the Maximum Permissible Limit which is 6376 N. If compressive forces exceed the MPL the lifting conditions should be considered unacceptable and the task be redesigned. Only 25% of men and less than 1% of women have the strength to lift loads above the MPL safely. If the force falls between the AL and the MPL, the lifting task should be considered unacceptable unless administrative or engineering controls such as careful selection of employees or task redesign are used.

3.0 SUMMARY OF RESULTS

The results from the Watback analysis on the 4 lifting tasks associated with the 20-ton hydraulic load frame are presented in Tables 1-4. The tables illustrate that all 4 lifts fall well below the Action Limit set by NIOSH which means that 99% of males and 75% of females can perform these lifts with nominal risk. The 4 lifts included; the lift of the 5' auger from the ground to the auger rack, the lift of the 5' auger from the platform to the auger rack, the one handed lift of the 5' Aw rod and the one handed lift of the 10' Aw rod.

The video analysis revealed a number of problems that can be easily corrected. These problems included such things as; the lack of foot support for climbing onto certain structures (Figure 4), the storage of Aw rods (Figure 5), storage of tools (Figure 6), and the unguarded exhaust (Figure 7).

The operators are often required to climb up different parts of the rig in order to fix something or get a look at a piece of equipment. They are often standing on very narrow supports so that there is a significant risk of falling. Falling injuries are one of the most frequently occurring injuries in the workplace and are a common cause of back pain.

The operator is constantly required to bend down and get Aw rods to attach them to the drive mechanism. The Aw rods are stored at about knee height and require a significant amount of bending. Repetitive bending such as this is a common cause of lower back pain.

The operator bends down often to get tools out of the tool box at the back of the rig. This is another example of repetitive bending that may increase the risk of musculoskeletal injury for the operator.

The noise level coming from the engine located on the surface of the rig may exceed safe limits. Exposure to high noise levels for significant periods of time can result in permanent hearing loss.

The exhaust represents a burn hazard if the operator comes into contact with the muffler.

The analysis revealed that the operators were well trained and very familiar with all aspects of operation of the rig. The two operators in this analysis are the only two technicians within Civil Research that are trained to work on this rig and as a result are the only ones who do.

Observation of lifting techniques exhibited by the operators revealed that they obeyed the three major principles of lifting in instances. The three major principles of lifting being; (1) keeping the load close to the body, (2) avoiding twisting, and (3) bending at the knees when lifting. However, their placement of tools and other equipment could be improved by placing them at waist height instead of at foot level.

4.0 CONCLUSIONS

Four common lifts associated with the 20-ton hydraulic load frame were analyzed and found to fall well within safe lifting limits set out by NIOSH. Video analysis revealed minor problems with rig design that can easily be corrected. Recommendations for improvement are listed under the next section.

5.0 RECOMMENDATIONS

Lifts involving the 5' auger at the back of the rig should be made from the platform provided (Figure 1) because the person is able to assume a correct posture when making the lift as opposed to the awkward postures that are assumed when lifting from the ground onto the rack.

The height of the bottom of the Aw rod rack should be increased to 60 cm to decrease the amount of bending the operator must do to reach the Aw rods on the rack.

The addition of foot supports to the areas where the operator must constantly be climbing up onto should be investigated. Foot supports would reduce the risks of falling injuries.

When the operator is using the tool box at the back of the rig (Figure 8), there should be a place at waist level at which the tool box can be located so that the operator is not required to constantly bend over to get tools.

A measurement of the noise level on and around the rig should be taken to see if it falls within safe limits. The measuring equipment needed can be attained from Mechanical Research. If excessive levels are found, a muffling device should be added to the existing engine.

A guard should be placed over moving parts of the engine (Figure 9) and over the existing exhaust (Figure 7).

If other personnel are to work on this rig, it is important that they receive extensive training to ensure that they are familiar with all aspects related to safe operation of the rig.

ACKNOWLEDGMENTS

The assistance of R.H.K. Tsang, Soil Sciences Section, Civil Research Department was appreciated. Mr. Tsang provided the opportunity to observe the tasks associated with the 20-ton hydraulic load frame.

Approved by:

J.B. Brown
Manager
Civil Research Department

Prepared by:

Shaun McCann

S.C. McCann
Human Factors Specialist
Civil Research Department

Reviewed by:

T.J. Carmichael
Supervising Engineer
Soil Sciences Section

SCMcC:LM

TABLE I

Lifting a 5' Auger from the Platform

Action Limit: 3433 N
Maximum Permissible Limit: 6376 N
Calculated Compression at L4-L5: 2908 N

Comments: Lifting a 5 foot auger from the platform onto the auger rack represents a nominal risk to most employees since the calculated value is well below the Action Limit. Lifting from the platform allows the operator to place the auger on its rack without having to reach out, reach up, or hold the auger away from its centre of gravity.

TABLE II

Lifting 5' Auger from Ground

Action Limit: 3433 N
Maximum Permissible Limit: 6367 N
Calculated Compression at L4-L5: 1341 N

Comments: The task results in compression forces on the L4-L5 disc that are well below the Action Limit set by NIOSH. However, the task does require a slightly more difficult lift than the same lift made from platform height in terms of the awkwardness of the lift because the person must hold the auger at lower level in order to lift it onto the pegs on the rack.

TABLE III

Lifting 5' Aw Rod on Top of Drill Rig with One Hand and Feeding Cable Through It

Action Limit: 3433 N
Maximum Permissible Limit: 6467 N
Calculated Compression: 1063 N

Comments: The compressive load on L4-L5 while lifting the 5' Aw rod with one hand poses a nominal risk to most employees. The only aspect of the task that could be improved is to bring the level of the Aw rod storage rack up to between waist and shoulder height.

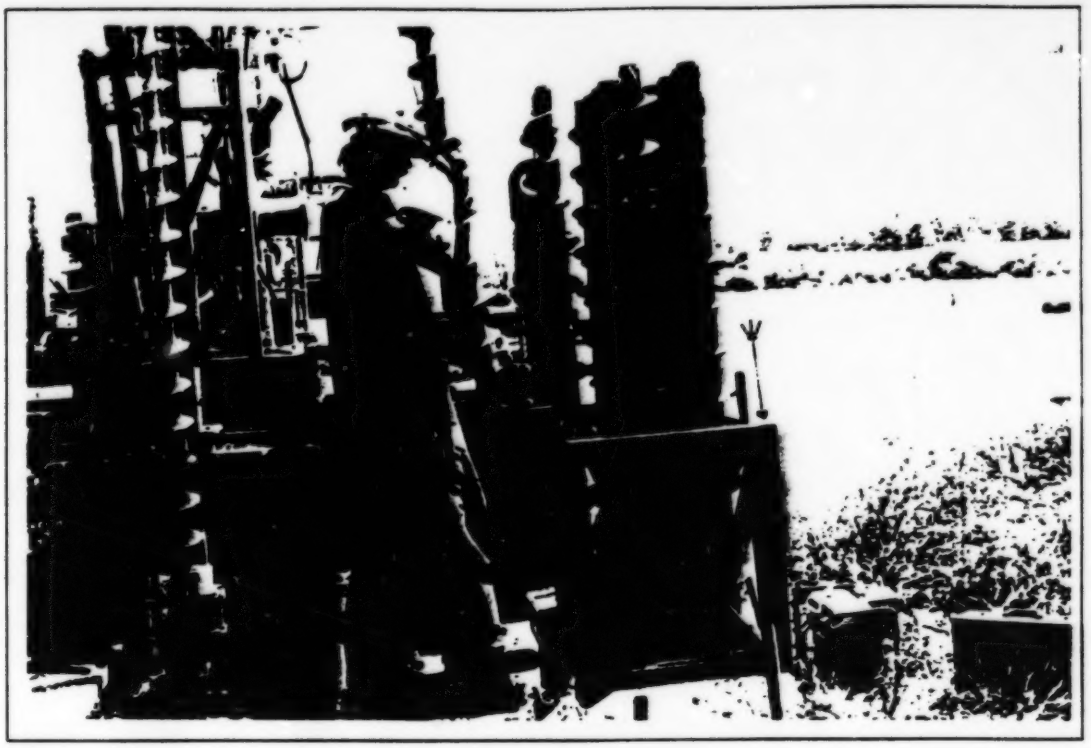

FIGURE 1

LIFT OF 5' FOOT AUGER FROM PLATFORM

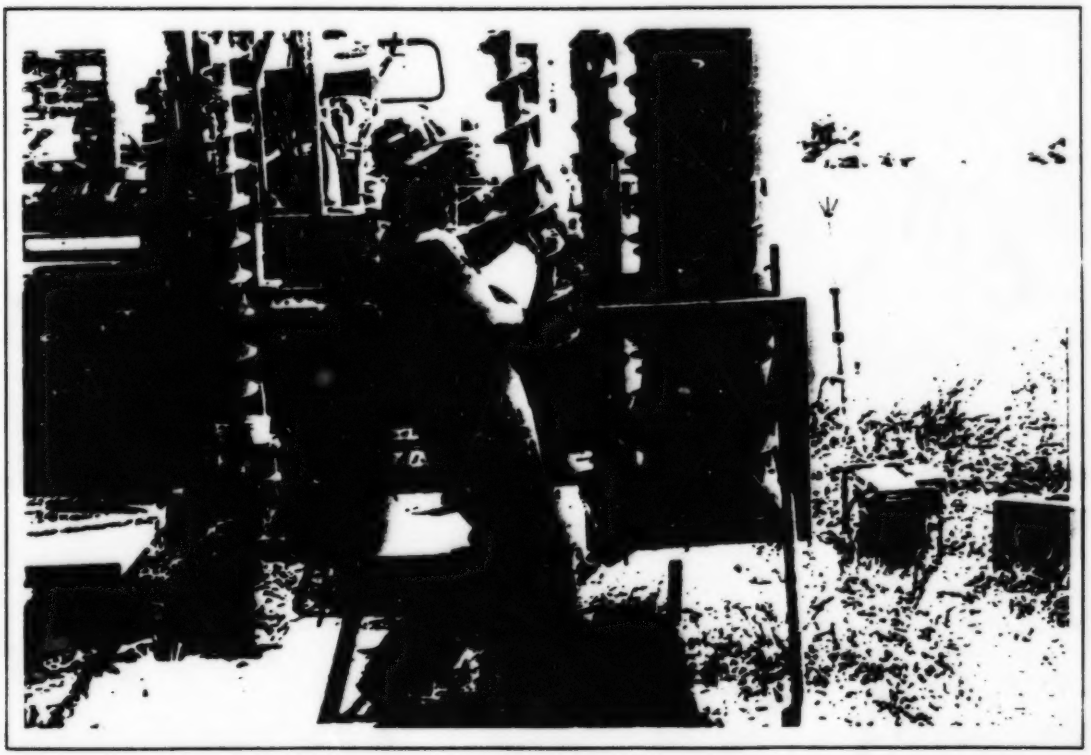

FIGURE 2

LIFT OF 5' AUGER FROM GROUND

FIGURE 3

ONE HAND LIFT OF 5' AW ROD

FIGURE 4

LACK OF FOOTING ON DRILL RIG

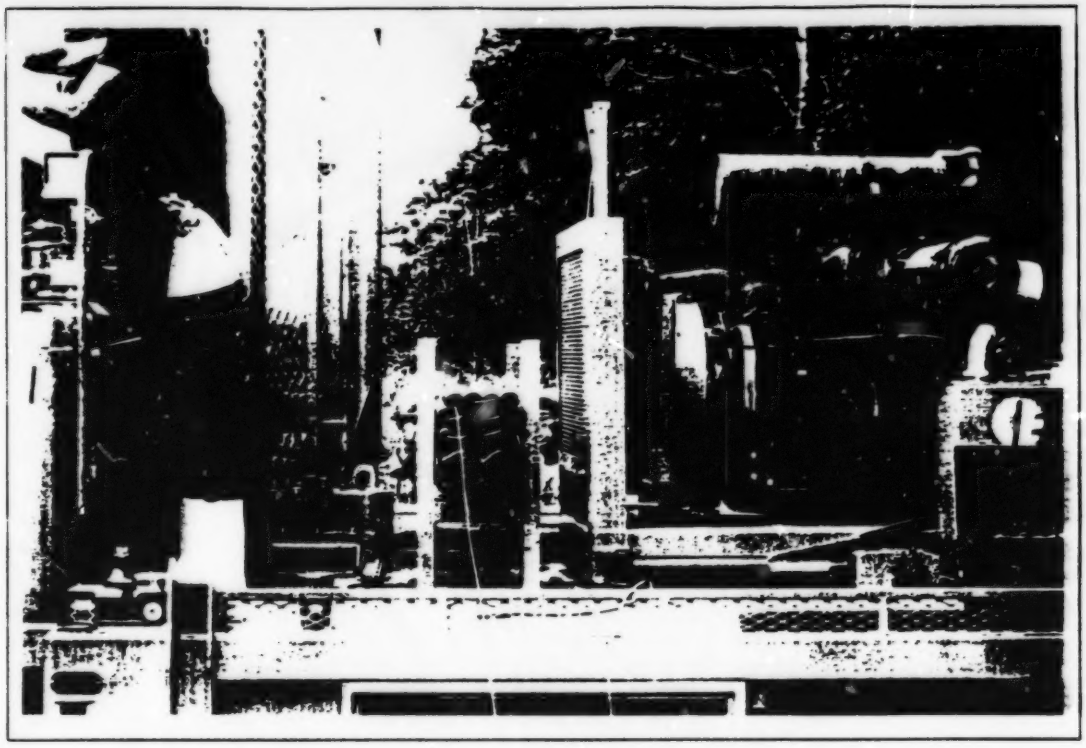

FIGURE 5

STORAGE OF AW RODS

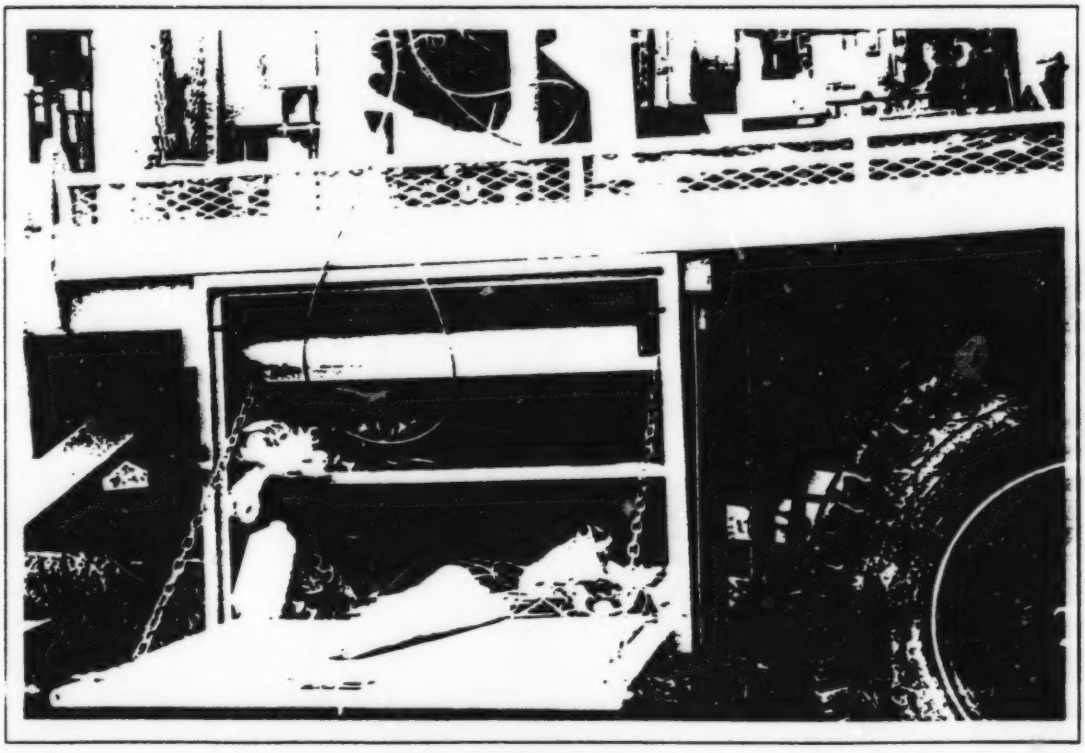

FIGURE 6

STORAGE OF TOOLS

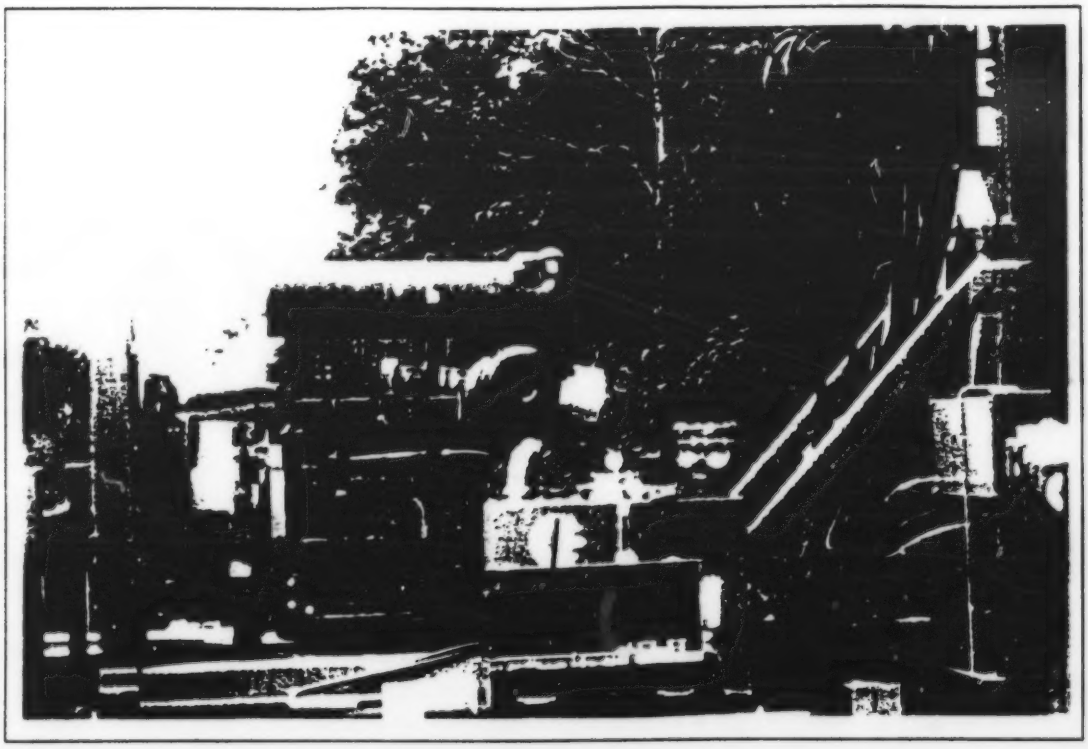

FIGURE 7

UNGUARDED EXHAUST

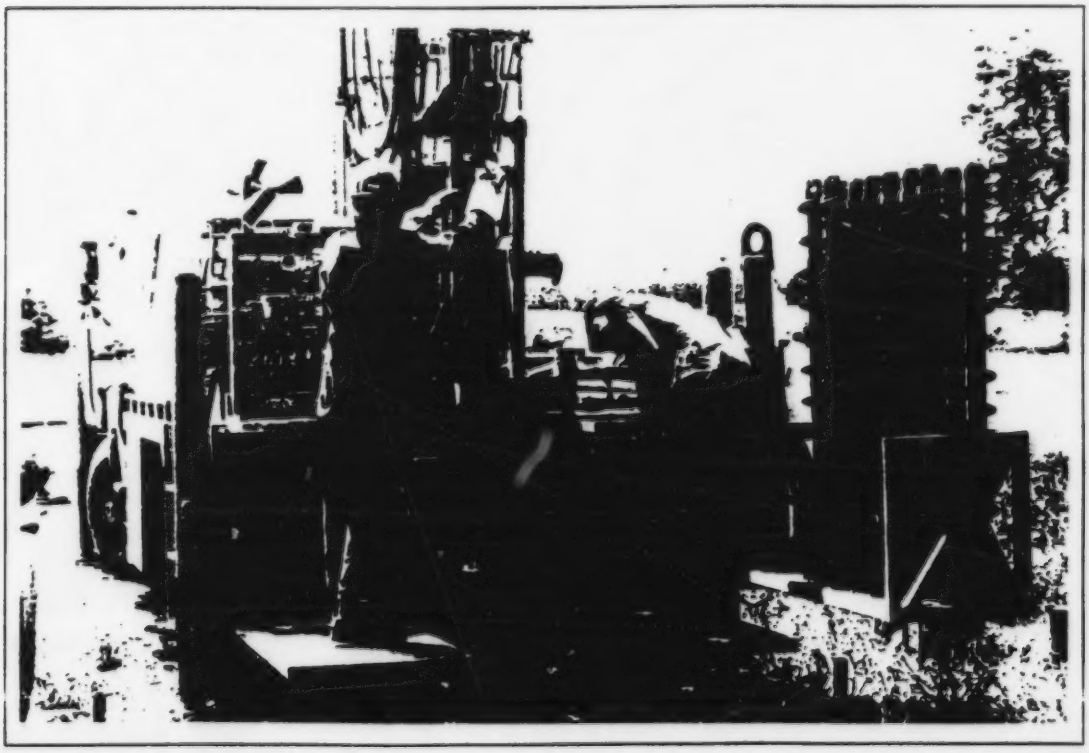

FIGURE 8

TOOL STORAGE

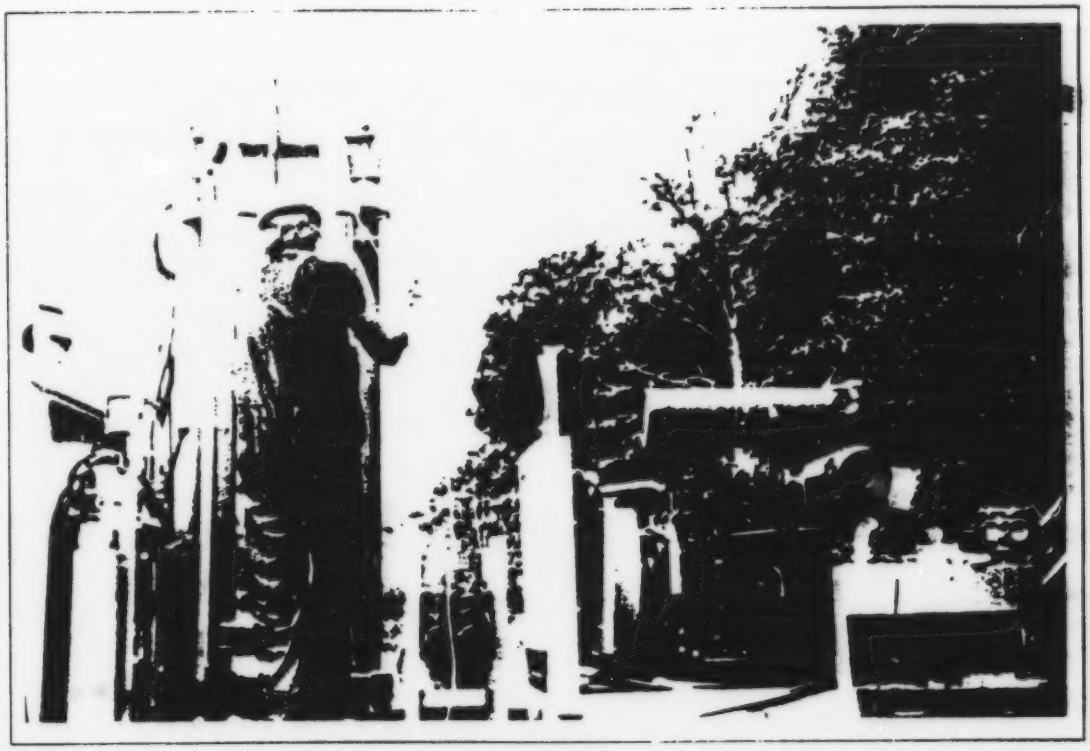

FIGURE 9

OPEN ENGINE

190484-B39-RD

DISTRIBUTION

Mr. M.L. Eisner
Mrs. K. Barlow
Mr. J.B. Brown/Mr. T.J. Carmichael
Mr. M.I. Grills
Mr. R.H.K. Tsang
Mr. S. McCann

Divisional Services, KR225
Health Services, KR298
Civil Research, KR251
Civil Research, KR252
Civil Research, KR252
Civil Research, KR252

Section File (1) KR252
Public Reference Centre
Research Publications Office
Office Copies (3)
Extra Copies (3)